SOIL SURVEY OF THE M'KENZIE AREA, NORTH DAKOTA.

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DESCRIPTION OF THE AREA.

The McKenzie area, comprising ten townships in the southwest corner of McKenzie County, is located in the extreme western part of North Dakota, equidistant from the north and south boundaries of the State. It is bounded on the north by township line 143 N. and east by range line 103 W.; on the south by Billings County, and on the west by the State of Montana. It is included between the meridians of 103° 44′ and 104° 2′ west longitude and the parallels of 47° 19′ and 47° 39′ 30″ north latitude and has an area of 222,784 acres, or about 348 square miles.

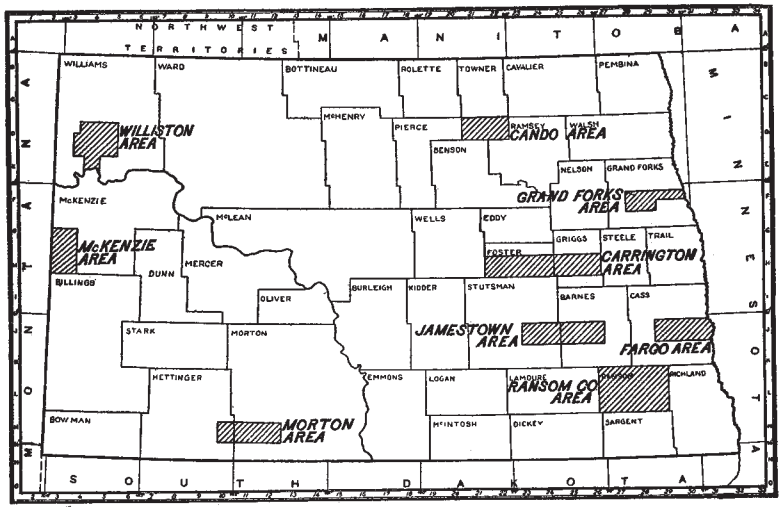

FIG. 29.—Sketch map showing location of the McKenzie area, North Dakota.

Through most of the region the surface features are extremely rough and broken. Within 2 miles of the southeast corner of the area flows the Little Missouri River, a stream widely known for the treachery of its channel and the extensive devastation wrought by its rapidly eroding tributaries. Because of the peculiar desolation of the tract along this stream the lands are known throughout the West as "Bad Lands," and though highly prized as a winter range for stock they are entirely unfit for cultivation.

The drainage of the region is exceptionally good. The divide between the Yellowstone and Little Missouri rivers passes in a northeasterly direction across the southeast corner of the area, from which

it will be seen the waters move chiefly westward to the Yellowstone. This river has a general northeasterly course and lies about 20 miles from the southwest corner and about 6 miles from the northwest corner of the area.

Though many stream courses are indicated on the map, none of them carry water except in the late fall and spring. The largest and most important of these streams is Bennie Pierre Creek, which, beginning near the southern line, winds in a northerly and westerly course to the northwest corner of the area. Entering this stream from the west and south are many smaller ones, which completely drain the central part of the area. Of these, Spring and One-Hundred-and-One creeks are the most important. From the north also flow several streams, the largest of which is Sheep Creek. Along these occur level productive valleys, which furnish the most desirable agricultural lands surveyed. A second divide, running east and west, occurs just south of the northern line of the area. Beyond this divide are several well-developed channels of drainage that also eventually reach Yellowstone River. Of these Shabeneau and Horse creeks are the largest and most important. In the southwest corner of the area Smith, the North Fork of Smith, and Poison Springs creeks provide excellent drainage. Flowing east into the Little Missouri River are a number of deeply cut streams, whose steep-sided laterals, branching and rebranching, have pushed back into the prairie and converted the region through which they pass into an intricate network of gullies and ridges. The largest of these dry waterways is Prairie Dog Creek—noted for the wide extent of rugged Bad Lands along its course. A peculiar feature of the drainage of the region is the occurrence of numerous "draws" or "gaps" connecting one drainage system with another. The most marked of these is "Hay Draw," a wide, level valley whose fall is so slight that for some distance on its crest the water at times takes a westerly course to the Yellowstone and at other times flows eastward to the Little Missouri. Other "draws" of this nature are Squaw Gap, Shadwell Gap, and one in the northwest corner of T. 146 N., R. 103 W., connecting Spring Creek with Bennie Pierre Creek.

Most of the people in the McKenzie area are ranchmen of considerable experience, having come to this region from the Black Hills country in South Dakota, where for years their stock enjoyed unlimited range.

The agricultural development of the McKenzie area has been greatly retarded by the absence of transportation facilities. The nearest shipping point to the south is Wibaux, Mont., on the Northern Pacific Railroad, 33 miles away. To the north the nearest shipping point is Williston, on the Great Northern Railway, 35 miles from the northern boundary line. Except one road to Wibaux no established roads lead from the area to either of these points. Thus it will be seen

that parts of the area are 50 miles from any shipping point. As yet no roads have been laid out, although well-established trails connect the various ranches. The region is very sparsely settled; only 12 ranches occurring within the area mapped. No agriculture is practiced, the people devoting their entire time to the stock-raising industry. This is due in part to the lack of transportation facilities and in part to the marked adaptability of the region to this special industry. About 9 miles to the west of the northern part of the area is the growing town of Sidney, Mont., but having no facilities for transportation it is of little use in disposing of the products of the area. All of the cattle raised are driven to Wibaux, Mont., or to Williston, and from these points shipped to Chicago.

CLIMATE.

In the study of conditions affecting agricultural development no factor is of greater importance than that of climate. This is especially true in a region where rainfall is uncertain and where killing frosts are apt to come during the period of crop growth. The McKenzie area is located in that part of the great central plain known as the semiarid belt. Throughout this region rainfall is so scant or so unevenly distributed that without irrigation, except in unusual years, successful crop production is possible only by the practice of systematic methods of intensive cultivation. Now and then a year is had when rainfall, if carefully conserved, is ample for crop production, but in the past such years have been the exception rather than the rule.

No climatic records have been kept within the limits of the McKenzie area, nor at any station where climatic conditions are precisely the same. At Williston, 35 miles north of the area, and at Oakdale, across the Little Missouri River, 40 miles east of the area, records have been kept, but at the latter point the rainfall is slightly increased and the temperature somewhat modified by the presence of the Killdeer Mountains. By reference to the data in the accompanying table, compiled from the records of the United States Weather Bureau at Williston, it will be seen that the average yearly rainfall at that place is 15.6 inches. This, it will be observed, is so distributed that over 50 per cent of the total amount falls during the three growing months of May, June, and July. It will also be seen that for these three months during the driest year only 3 inches of rainfall was had. During the wettest year 13.7 inches is recorded for these three months, which, if properly handled, is quite sufficient for the production of crops. But it should be noted, too, that for this wet year the total precipitation for the four months preceding May was only 1.5 inches. By comparing these conditions with those which prevail in the eastern part of the State it will readily be seen that the degree of success attending the efforts of the farmer in the east can not be hoped for in the McKenzie area, unless more intensive methods of

cultivation are resorted to. From a study of the tables it would seem that climatic conditions at Oakdale are somewhat more favorable for agricultural operations than are those reported at the Williston station. Here the rainfall for the driest year was 15 inches, about 50 per cent of which was well distributed throughout the growing season. The mean temperature throughout the year is slightly higher than at Williston, though this increase is all recorded for the winter months, the growing season being somewhat cooler. At Williston temperatures of 100° F. or more are recorded for May, June, July, August, and September, while at Oakdale the temperature has reached 100° F. only during July and August. The lowest temperature recorded at Williston is —49° and at Oakdale —41° F.

The average date of the last killing frost in spring, as recorded at the Oakdale station, is May 2, and of the first in the fall September 15, giving an average growing season of 136 days. At Williston the average date of the last killing frost in the spring is May 18, and of the first in the fall September 14, which gives an average growing season of 119 days. The latter figures probably closely represent the average conditions in the McKenzie area, although during the present year (1907) a killing frost occurred on August 2.

The annual snowfall of the region is rather heavy, the average being 39.6 inches at Williston and 43 inches at Oakdale. This interferes to a great extent with winter grazing, except in the rough broken land. Here the snow is blown away, leaving sufficient vegetation to supply the herds of horses and mature cattle which are allowed to graze.

The following tables give the normal monthly and annual temperature and precipitation, the absolute maximum and minimum temperatures, the snowfall, and the amount of precipitation for the driest and wettest years for the two stations mentioned above:

Maximum, minimum, and normal monthly and annual temperature.

Month.	Williston.			Oakdale.		
	Mean.	Absolute maximum.	Absolute minimum.	Mean.	Absolute maximum.	Absolute minimum.
	°F.	°F.	°F.	°F.	°F.	°F.
January	6	52	—49	16	59	—32
February	8	57	—46	13	56	—41
March	22	72	—35	23	66	—22
April	43	92	— 4	44	87	16
May	55	101	11	55	92	20
June	63	107	30	62	98	31
July	69	106	37	68	101	40
August	67	107	34	66	100	36
September	56	100	17	56	93	24
October	44	95	— 3	45	78	4
November	25	69	—29	26	72	—22
December	14	59	—46	21	56	—27
Year	39	107	—49	41	101	—41

Maximum, minimum, and normal monthly and annual precipitation.

Month.	Williston.[a]				Oakdale.[b]			
	Mean.	Total amount for driest year.	Total amount for wettest year.	Snow, average depth.	Mean.	Total amount for driest year	Total amount for wettest year.	Snow, average depth.
	Inches.	*Inches.*	*Inches.*	*Inches.*	*Inches.*	*Inches.*	*Inches.*	*Inches.*
January	0.6	0.1	0.1	6.6	0.4	0.7	1.4	3.9
February	.5	.1	.5	5.4	.7	1.4	.6	7.6
March	.7	.1	.2	6.8	1.6	1.8	.4	13.4
April	1.3	1.3	.7	4.0	1.3	1.6	.6	5.1
May	2.1	.1	4.0	1.6	3.2	.7	7.8	.6
June	3.6	1.0	5.5	.0	4.1	2.6	2.3	Trace.
July	2.2	1.9	4.2	.0	2.1	1.4	4.6	.0
August	1.7	1.1	2.4	.0	1.3	2.5	4.0	.0
September	.8	.5	1.0	Trace.	1.2	.3	1.9	Trace.
October	.9	.5	.9	2.2	.6	.4	.4	2.1
November	.6	.3	.7	6.9	.8	.9	.4	7.4
December	.6	.4	3.1	6.1	.6	.7	1.6	2.9
Year	15.6	7.4	23.3	39.6	17.9	15.0	26.0	43.0

[a] Average date of last killing frost in spring, May 18; first in the fall, September 14.
[b] Average date of last killing frost in spring, May 2; first in the fall, September 15.

AGRICULTURE.

As yet no attempt has been made to introduce agriculture into the McKenzie area. Here and there a small garden is planted to vegetables for home consumption, but the total acreage under cultivation does not exceed 20 acres. To the south 15 or 20 miles, where transportation facilities are not so distant, a few scattering homesteads have been taken up within the last five years, and the growing of small grains is being introduced. On the west no agriculture is found until the valley of the Yellowstone is reached, where the irrigation ditch being constructed by the United States Government is having marked effect in stimulating agricultural development. From the north during the last two years settlers have been gradually pushing south, a few having nearly reached the northern limits of the area surveyed. On the east side of the area the rough broken lands along the Little Missouri soon begin and continue for several miles beyond the river, thus effectively checking the advance of homestead settlements from this direction.

The leading industry practiced in the McKenzie area is the livestock industry. Diseases which so commonly affect the stock in latitudes farther south are here unknown, and cattle, horses, and sheep are raised at nominal cost. In the early years of ranching little attention was given to the care of the stock, but lately it has been found that a supply of hay during the winter months is an excellent insurance against loss. Only the weaker animals, however, ever need to

be fed, the larger part of the herds getting their subsistence unaided. During the winter, when the main body of the herd is allowed to run uncared for on the plains, the animals become widely scattered and sometimes drift for many miles from the owner's range. About May 1 the general round-up is begun, when all the cattle are collected and driven back to their respective ranges. Here the calves are corralled and marked with the owner's brand, after which they are again returned to the herd and allowed free range upon the plains. About the middle of July, soon after the general round-up is completed, the haying season begins and continues until the gathering of the beef herd takes the men from the field. This is usually about September 20. At this time little attention is given to the stock other than that intended for shipment, which usually includes no animals less than 4 years old. During the late fall months, before winter sets in, the range is gone over again and all the calves and the less vigorous animals, which, if uncared for, would be apt to succumb during a period of deep snow, are collected and driven to the home ranch or where stacks of hay have been provided for winter feeding. Here they are cared for during the hardest winter months, the hay being hauled and scattered on some convenient feeding ground at the rate of 1 ton per day for every 100 head. As the period of actual feeding never exceeds 100 days, 1 ton of hay is considered amply sufficient for each animal intended to be fed.

When horses are kept no provision is made for their maintenance during the winter months. The areas of rough broken land are largely their range, as here the snow blows away, leaving the vegetation bare, while the numerous deep ditches with precipitous walls closely encircled by steep-sided hills provide an excellent shelter from the winter winds and storms.

Those who keep sheep are usually prepared for the severities of the winter. Good warm sheds are provided, and if the snow becomes too deep or the weather unusually bad hay is hauled and fed near these at the rate of about 2 tons per day for every 1,000 head of sheep. If, on the other hand, the winter be open and the ground sufficiently free from snow, no hay is required; the sheep are turned out on the range and herded on the spots where the snow has blown away, being returned to the sheds only at night or on unusually bad days. Thus it is seen that the duties of the ranchmen require help the year around. As a rule, the labor secured is reliable and efficient. The busiest season, when help is hardest to obtain, is in the early spring months and in the summer, when the hay is being cut. At these times the wage paid ranges from $45 to $65 a month. During the winter months, when the work is light and fewer men are needed, sufficient help can be secured for $45 a month. Owing to the trying solitude of a sheep

herder's life, his services command a relatively higher price, this work rarely being done for less than $65 a month.

Throughout the region are found extensive deposits of valuable lignite coal. In the mapping of the area no effort was made to indicate the localities in which the material appeared, although there were many places in which the veins were prominently exposed. From the frequency with which these exposures occur it will be seen that fuel, even though the region be treeless, is abundant. The importance of this for home consumption in a section so far removed from railroads can hardly be overestimated.

The McKenzie area, though primarily a grazing district, is capable of considerable development in an agricultural way. Through the area run a number of broad, level bottoms whose drainage channels, though dry during the greater part of the year, carry immense volumes of snow water during the early spring thaws. This water, if utilized, would be one of the most valuable assets the area possesses. By its use the valleys could be made to produce large quantities of alfalfa hay—a crop which would be especially valuable in this region. Small grains could also be produced, but under the present conditions of transportation these crops would not prove so profitable as would one which could be fed directly from the field and from which much of the cost of expensive marketing is eliminated. Though the region is somewhat arid for the best results on the upland soils, it is probable that with thorough cultivation fair yields could be secured. As the soils receive but little rainfall after the crops are planted, the question of conserving soil moisture at the time of plowing is a very important one. On account of the dryness of the climate and the roughness of the topography, the area as a whole is better fitted for grazing purposes than for the growing of cultivated crops, and for this reason haste should not be made to destroy by uncertain cultivation the nutritious prairie grasses, which now dominate the uplands and which are of such inestimable worth to the live-stock industry.

SOILS.

The geographic position of the McKenzie area in the semiarid belt, as well as its geologic position on the lower line of glaciation, has a marked effect on the character of the various soil materials. In the southern part of the area the soils are largely the residual ones of the western prairie regions, while in the northern part they partake both of the nature of this soil province and also of the glacial province. As is common throughout the western prairie regions, the soils possess a high percentage of silt, but the content of organic matter is here somewhat less than is usually found in prairie soils

and the color is considerably lighter. No large bodies of any one type occur in any part of the area—a condition due to some extent to the active erosion which has taken place.

In a general way the soils may be divided into two general groups—the upland or residual soils and the lowland or alluvial soils. Of the former there are six distinct types and of the latter two. As the area occupies the divide between the Yellowstone and Little Missouri rivers, portions of it are very rough and rugged. In the southeast corner, where the divide is most pronounced and where the deeply cut streams have worked their way up from opposite sides nearly to the summits of the hills, this condition exists to a very marked degree. In such places, which are locally known as Bad Lands, the soils occur so badly mixed that detailed classification is impracticable and they have been indicated in the map under the general name of Rough broken land. Farther down the streams, where the channels are older and better established, the valleys widen out and give rise to the two alluvial soils—the Wade silt loam and the Wade clay. These soils are composed chiefly of the materials washed down from the Rough broken land and constitute the most valuable soils in the area. On the uplands the most common type is Morton silt loam—a soil of distinctive texture formed by the weathering of fine-grained sandstone. Other types formed from this material are the Morton fine sand and Morton fine sandy loam. Their occurrence, however, is not extensive.

The most prominent feature of the area is the presence of high, red ridges of Scoria gravel. This shalelike material is found in all parts of the area, and aside from its deposits of lignite coal is valuable only as pasture for stock. Its formation is due to the weathering of materials formed by the heat of burning coal beds. Morton stony loam is the most limited soil in the area and is the only one in which the effects of glaciation are apparent. The gravel is only a thin glacial covering overlying the materials of the adjacent soils and is not found in the area south of the northern tier of sections in T. 146 N., R. 104 W. This location is of interest in that it marks for this region the lower line of glaciation.

To the north and east of this line an impervious clay loam soil occupies the greater part of the area. This soil is notable for the frequent occurrence of small, depressed areas on which the vegetation has been destroyed either by the sliding of the water-soaked soil or by the burning action of alkali. In this respect the type resembles the Carrington clay loam of the Carrington area. The two differ, however, in that the Carrington clay loam is a glacial-formed soil, while the Morton clay loam is residual.

The table following gives the names of the several soils and the area which each covers.

Areas of different soils.

Soil.	Acres.	Per cent.	Soil.	Acres.	Per cent.
Morton silt loam	104,576	46.9	Morton clay loam	15,872	7.1
Scoria gravel	25,920	11.7	Wade clay	7,680	3.4
Wade silt loam	25,216	11.3	Morton fine sand	3,072	1.4
Morton fine sandy loam	21,568	9.7	Morton stony loam	896	.4
Rough broken land (Bad lands)	17,984	8.1	Total	222,784	

MORTON SILT LOAM.

The soil of the Morton silt loam consists of 6 to 10 inches of gray or yellowish-brown friable silt loam. The subsoil, to a depth of 2 feet, is a yellowish-gray silt loam or silty clay, beneath which occurs a compact silty clay of a somewhat lighter color. On account of the accumulation of organic matter in the surface foot, the structure of the soil when dry is fairly loose and open, making it a comparatively easy soil to cultivate.

On the level or gently rolling areas, where drainage is good, the friable yellowish-gray material extends to a considerable depth, but where the type is in the vicinity of the Rough broken land or where the drainage is poor the yellow color soon disappears and the material becomes a sticky, compact clay having all the characteristics of gumbo. These areas, though numerous, are all so small in extent that none could be shown on the map as a separate type.

The Morton silt loam, by reason of its extensive acreage, is one of the most important soil types in the area surveyed. It is found in all parts of the area in both large and small bodies, though its most typical development is seen near the southwest corner between Smith Creek and the north branch of this stream. Other typical bodies are found along the sides of Spring Creek in T. 147 N., R. 104 W., and on each side of One-Hundred-and-One Creek in T. 147 N., R. 105 W. Here the type occurs in comparatively large bodies, broken to some extent by narrow valleys of Wade silt loam and irregular ridges of Scoria gravel.

The greater part of the Morton silt loam has a sloping or gently rolling topography. This is especially true of the type along the North Fork of Smith Creek and in nearly all of the western half of the area. As the soil when wet is more or less sticky and adhesive, the sloping topography, if not too steep, is a decided advantage, for it insures excellent surface drainage and would permit of early cultivation and seeding in the spring. In the eastern part of the area, where the type occurs in small bodies closely associated with the Rough broken land, the topographic features are so rough and rugged that any attempt at cultivation would likely prove a failure.

Throughout most of the region surveyed the Morton silt loam is a residual soil, being derived in place through weathering from fine-grained sandstone. On the sloping sides of valleys, however, where the descent is very gentle, the type is both residual and colluvial in formation. Here and there throughout the areas, small mounds and ridges are sometimes found capped by angular fragments of brownish-yellow flintlike rock, which, from their prominent position, give the type the appearance of having a more broken topography than it really possesses. Large sandstone concretions from 3 to 10 feet in diameter and from 50 to 100 feet in length are also frequently found on the higher elevations. Where these occur the soil is apt to contain a small amount of very fine sand and the topography is usually more or less broken.

Throughout the areas of this soil in the northwest part of the survey narrow ridges of fine glacial gravel are occasionally seen, but most of them are too small to appear on the map as a separate type.

As a rule, the Morton silt loam is fairly free from alkali; however, on the lower levels and in the vicinity of buttes, where the surface soil has been removed, a thin, white crust is sometimes seen, indicating that salts are present to some extent.

Throughout the area the soil is treeless, the vegetation being the native grasses common to the plains. When this is mowed the yield ranges from one-third ton to 1 ton per acre. None of the soil has ever been broken up for cultivation, and probably not more than 2 per cent of its total acreage is mowed for hay. The type is almost wholly used for grazing, for which it is well adapted. Of the upland soils this is the most suitable for agricultural purposes, and with thorough tillage and favorable seasons a fair degree of success would doubtless result from its cultivation. Small grains, hay, and potatoes should do well on this type if sufficient rainfall is had. On account of its higher position and consequent greater freedom from frosts the soil is the best in the area for the production of corn, but only in exceptional years could this crop be matured before the appearance of frosts.

The following table gives the average results of mechanical analyses of the soil and subsoil of the Morton silt loam:

Mechanical analyses of Morton silt loam.

Number.	Description.	Fine gravel.	Coarse sand.	Medium sand.	Fine sand.	Very fine sand.	Silt.	Clay.
		Per cent.	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent*
17032, 17660	Soil	0.4	3.0	2.1	6.5	8.3	66.3	13.0
17033, 17661	Subsoil	.1	.6	.2	1.2	4.9	78.5	13.4

The following samples contained more than one-half of 1 per cent of calcium carbonate ($CaCO_3$): No. 17032, 14.38 per cent; No. 17033, 24.60 per cent; No. 17660, 30.87 per cent; No. 17661, 20.75 per cent.

WADE SILT LOAM.

The Wade silt loam consists of 6 to 10 inches of dark-brown to black silt loam containing a high percentage of organic matter. The subsoil is usually a light-brown or brownish-yellow silt loam or silty clay similar in appearance to that of the Morton silt loam. When dry, both soil and subsoil are fairly loose and open, making it a comparatively easy soil to cultivate. When wet, however, the high clay content renders it sticky and adhesive. In a few places, where the fine material of Morton silt loam has recently washed in and vegetation has not had time to recover its growth, the surface is much lighter in color, sometimes presenting an ashy appearance, similar to that of the upland silt loam. Such areas are found in the western part of T. 147 N., R. 103 W., and in T. 147 N., R. 104 W., in the lowlands along Bennie Pierre Creek.

The Wade silt loam, though of small extent, is one of the best and most important soils in the area. It is seen only in the valleys of streams or dry waterways and in the narrow gaps which are sometimes found separating hills of Scoria gravel. The chief bodies occur as long, narrow strips on the flats of Bennie Pierre, Spring, and One-Hundred-and-One creeks and along the sides of Hay Draw. Other important bodies are found on the forks of Smith Creek, O'Brian Creek, and in Judd, Squaw, and Shadwell gaps.

The surface of the Wade silt loam is quite level, having only a very gentle slope from the banks of the streams to the beginning of the highlands. Hence in the spring the waters from the melting snows do not run off at once, but remain on the ground for several days. Later in the season, when the upland soils are dry, the influence of the standing water can still be seen in the more moist condition of this soil.

In origin the soil is alluvial, being formed partly by the overflow of streams in spring and partly by the wash of materials from the higher lying soils.

In the southern part of the area, along the forks of Smith Creek, alkali spots are frequently found, and where they occur vegetation is very scant and sometimes entirely lacking. These spots are all small in extent—usually not more than 3 or 4 rods across—but in the aggregate they occupy a considerable area of the soil in this vicinity. Farther to the north, along Bennie Pierre Creek, the soil does not seem to be seriously affected, although the water in the stream is strongly alkaline.

The type supports a luxuriant growth of rich native grasses, for which it is highly prized. Along the courses of Spring and Bennie Pierre creeks are found valuable trees of cottonwood, box elder, and

elm. These trees are usually rather small and short of trunk, except the cottonwoods, which occasionally reach the size of 3 feet or more in diameter. At the heads of valleys and here and there throughout the type are small areas densely covered by a low growth of wolfberry brush (*Symphoricarpos occidentalis*). This growth, locally known as buckbrush, marks the location of the best soil in the area for general agricultural purposes; for in these positions the drainage is excellent and the black, moist soil extends to a depth of several feet. The areas, however, are usually small, rarely exceeding 40 acres in extent.

With proper handling the soil is well adapted to a wide variety of crops. Alfalfa, small grains, potatoes and turnips and other root crops should do well. None of this soil is under cultivation in the area, except a few small patches used principally for garden purposes. In these potatoes yield from 100 to 150 bushels per acre, and fair yields of wheat and oats are secured. About 5 per cent of the area of this soil is annually mowed for hay, the yield ranging from one-half ton to 1½ tons per acre, with an average yield of about 1 ton per acre. This small portion of the type yields about 90 per cent of all the hay cut in the area. The soil provides a large amount of excellent summer pasturage, but is considered too open for good winter range.

By utilizing the snow water in the spring this soil could doubtless be profitably irrigated. This could be done by throwing up embankments across the narrow places in the valleys, and after the water had been used to flood the soil above, it could be drawn off and utilized again to irrigate the valley below. In using water in this way, however, care should always be observed not to apply to the lower fields water that had become too salty as a result of flooding other fields.

The following table gives the average results of the mechanical analyses of the soil and subsoil of this type:

Mechanical analyses of Wade silt loam.

Number.	Description.	Fine gravel.	Coarse sand.	Medium sand.	Fine sand.	Very fine sand.	Silt.	Clay.
		Per cent.	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*
17040,17669	Soil	0.0	1.2	1.2	10.5	9.6	58.8	18.4
17041,17670	Subsoil	Tr.	.8	.7	11.2	9.3	58.6	19.4

The following samples contained more than one-half of 1 per cent of calcium carbonate ($CaCO_3$): No. 17041, 2.43 per cent; No. 17670, 7.49 per cent.

WADE CLAY.

The Wade clay consists of about 6 inches of heavy clay loam or clay, varying in color from gray or light drab to black, resting on a

subsoil of stiff, heavy clay, with a somewhat lighter color than the soil. When dry the surface bakes exceedingly hard, and cracks 2 feet in depth and 1 inch or more across are not infrequent. Under the influence of water the soil becomes sticky and plastic, making it a difficult one to cultivate. From this fact the type is locally known as "gumbo," though it does not possess the waxy, tenacious property to the same degree as is found in gumbo of other areas.

About 12 square miles of Wade clay are found in the McKenzie area. The type occurs along the streams in narrow strips ranging from one-eighth to one-half mile in width. The principal bodies are found in the eastern part of the area, along Hay Draw, Bennie Pierre Creek, and the tributaries of this stream. Other lesser bodies occur in T. 145 N., R. 104 W., along the forks of Smith Creek, and in T. 146 N., R. 104 W., in the vicinity of Spring Creek. The areas have a level topography and are found only in the lowest parts of the draws and valleys. Because of this position the drainage is usually poor.

The origin of the soil is alluvial, the materials from which it is derived having been left by the waters of repeated overflows. On account of its low position and poor drainage, most of the soil is somewhat affected by alkali. This is evidenced by the numerous bare spots and the scant growth of grass which covers small areas here and there throughout the type. In the lowest places a few scattered trees of cottonwood, box elder, ash, and elm are occasionally seen, which adds considerably to the value of the type.

The Wade clay is naturally a strong soil. If properly drained and supplied with sufficient moisture, it would be well suited not only to the native wild grasses of the region, but to tame grasses, alfalfa, and small grains as well. Except in Hay Draw, the larger part of the areas of this type of soil is used only for pasture. Here the soil does not seem to contain much alkali, and a heavy growth of wild hay is produced each year. Nearly all of this draw is mowed for hay, the yield ranging from one-half ton to 1 ton per acre, with an average yield of about three-fourths ton.

Like the Wade silt loam, this soil would be much improved by irrigation. Although no water is available for this purpose, after the freshets in spring this could easily be accomplished by making use of the large volume of snow water. With proper subdrainage provided, one thorough flooding each spring would remove the greater part of the injurious salts and by supplying moisture well into the growing season would make the soil a highly productive one, whereas in its present condition its agricultural value is relatively low.

The following table gives the results of the mechanical analyses of the soil and subsoil of this type:

Mechanical analyses of Wade clay.

Number.	Description.	Fine gravel.	Coarse sand.	Medium sand.	Fine sand.	Very fine sand.	Silt.	Clay.
		Per cent.	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*
17038	Soil	0.0	0.1	0.2	2.6	1.8	52.1	42.8
17039	Subsoil	.0	.1	.2	3.4	2.3	51.1	42.2

The following samples contained more than one-half of 1 per cent of calcium carbonate ($CaCO_3$): No. 17038, 1.54 per cent; No. 17039, 2.72 per cent.

MORTON FINE SAND.

The soil of the Morton fine sand is a brown fine sand from 5 to 8 inches deep, usually containing a considerable quantity of organic matter. Below this depth the organic matter disappears and the material becomes a clean, gray fine sand, which overlies a gray silt loam from 3 to 5 feet deep. Both soil and subsoil have an open porous structure, though when thoroughly saturated with water the organic matter in the soil gives the surface a slightly compact appearance.

The Morton fine sand is not an extensive type in the McKenzie area, being found only in a few small bodies on the tops of hills and ridges. As a rule it is closely associated with areas of Morton fine sandy loam, into which it gradually merges with no distinct line of demarcation. The chief bodies occur in the eastern part of the area in T. 145 N., R. 103 W., and T. 147 N., R. 103 W.

Except where the areas occupy a plateaulike eminence, the topography is rolling. This, together with the open structure of the soil, is apt to give a too rapid removal of the rain water in the spring and cause the soil to suffer from drought during the drier, summer months.

The Morton fine sand is a residual soil formed by the weathering of fine-grained sandstone, exposures of which are of frequent occurrence throughout the type. In favorable seasons the soil supports a good growth of native grasses, but in dry years it suffers badly from drought and at such times the vegetation is scant.

None of the Morton fine sand is under cultivation in the area, nor is any of it mowed for hay. On account of the loose, open structure and the rapid drainage of the type it is one of the earliest soils, and for this reason is of value for spring pastures. Early in summer, however, the uncultivated soil dries out and the grasses cease to grow. If thoroughly tilled the soil should be adapted to potatoes, truck, and all garden crops, but is somewhat too light to be used successfully for continuous heavy cropping.

The following table gives the results of mechanical analyses of the soil and subsoil of this type:

Mechanical analyses of Morton fine sand.

Number.	Description.	Fine gravel.	Coarse sand.	Medium sand.	Fine sand.	Very fine sand.	Silt.	Clay.
		Per cent.	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*
17036	Soil	0.0	0.4	0.8	53.6	11.4	30.4	3.0
17037	Subsoil	.0	.7	.8	42.4	27.1	23.4	6.2

The following samples contained more than one-half of 1 per cent of calcium carbonate ($CaCO_3$): No. 17036, 1.91 per cent; No. 17037, 5.27 per cent.

MORTON FINE SANDY LOAM.

The soil of the Morton fine sandy loam consists of about 10 inches of brown fine sand or fine sandy loam. This is usually underlain by gray or light-brown fine sandy loam of a somewhat heavier texture. On the sides of hills and where the type is in close proximity to bodies of Morton silt loam, the subsoil is a gray or yellowish-brown silt loam, similar to that of the Morton silt loam. The structure of the surface soil is loose and open, rendering it an easy type to cultivate.

The Morton fine sandy loam is a common type in the McKenzie area, especially in the southern part. The most prominent bodies occur in T. 145 N., and R. 103 and 104 W., though minor areas are found in every township in the survey. The type occupies low swells and ridges in the prairie and has a moderately rolling topography. On account of this position, the soil is thoroughly drained and cultivation can be carried on almost immediately after heavy rains.

The Morton fine sandy loam is derived from the weathering of fine-grained sandstone, ledges of which are frequently seen capping the highest places throughout the type. This soil supports a good growth of native prairie grass, but owing to the abundance of more level hay land along the streams none of it is used for hay.

The type is treeless and open, and as it occupies a position exposed to the winds it is held in low esteem, except for summer grazing. However, in favorable seasons if properly cultivated this soil should produce a variety of crops. The good drainage and the high position give it a certain degree of freedom from frosts. Although as yet the production of corn has not been a success in this region, it is quite probable that in favorable years, with quick maturing varieties and thorough cultivation, gratifying yields could be secured. Potatoes should do especially well on this type, and all other crops that can be given thorough cultivation. Though fair yields of small grains could doubtless be produced, the soil is not so well adapted to these crops as are some of the heavier soils of the area. None of the Morton fine sandy loam is under cultivation.

The following table gives the average results of mechanical analyses of the soil and subsoil of this type:

Mechanical analyses of Morton fine sandy loam.

Number.	Description.	Fine gravel.	Coarse sand.	Medium sand.	Fine sand.	Very fine sand.	Silt.	Clay.
		Per cent.	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*
17034,17658	Soil	0.1	0.9	0.8	40.8	10.1	41.1	6.5
17035,17659	Subsoil	.1	1.7	1.1	20.9	6.6	47.5	21.7

The following samples contained more than one-half of 1 per cent of calcium carbonate ($CaCO_3$): No. 17034, 0.69 per cent; No. 17035, 13.35 per cent; No. 17659, 7.76 per cent.

SCORIA GRAVEL.

Scoria gravel consists of bright red shalelike gravel from 6 to 10 inches deep. Below this depth the particles become coarser and more angular in shape, grading finally into solid rock at 2 to 3 feet below the surface. The small quantity of interstitial material found is usually a brown fine sand or fine sandy loam, although in places where the elevation of the area is not too high it consists chiefly of gray silt loam.

Scoria gravel is found in all parts of the McKenzie area, usually as long, narrow ridges or as a succession of steep-sided buttes. The chief bodies occur in the east and central parts of the area in Ts. 145 and 146 N., R. 103 W., and in T. 147 N., R. 103 W. Owing to the loose, open structure of the soil and the rough, broken topography, the rainwater is immediately borne away, so that in nearly every case the soil is excessively drained.

Scoria gravel is a residual soil probably formed through the agency of heat. Although more or less dispute is frequently heard as to the source of this great heat, it is highly probable that its immediate cause was the burning of vast fields of lignite coal. As the heat died out the molten mass solidified, taking a great variety of shapes. Under the influence of subsequent weathering, particles of the rock have chipped and broken off, till now the mass is little more than shalelike gravel, surrounding now and then a more resistant core of the solid rock. Because of the bright red color and the prominence of its position on the highest elevations the soil is one of the most conspicuous to be found in the West.

Magnetic iron is found to some extent in this material, though it is doubtful if the quantity is sufficient to make it of commercial interest. Lignite coal is also found, and its presence will in time add considerably to the value of the land.

On the higher elevations, where the material consists chiefly of gravel and the drainage is excessive, sagebrush and cactus share the ground with the scant growth of grass. Leading up into the hills,

however, from the streams and valleys are narrow, winding coulées,[a] too limited to be mapped. These, receiving the drainage of the hills, produce a good growth of grass, and, being protected from the winter winds by the adjacent highlands, furnish a large amount of both summer and winter pasturage.

On account of the rough topography and the open gravelly structure of the soil, the Scoria gravel is of little value, aside from the pasturage which it affords.

MORTON CLAY LOAM.

The soil of the Morton clay loam is a brown loam or fine sandy loam from 0 to 6 inches deep. At an average depth of 4 inches the soil is underlain by stiff, heavy clay, ranging in color from dark gray or drab to black. When wet the subsoil becomes a dark slate color and is very sticky and plastic. As it dries small fissures are formed and the material becomes hard and impervious. This is especially noticeable where the surface materials have been washed away, leaving the clay exposed. Where this condition exists the type is locally known as "gumbo."

The chief bodies of Morton clay loam are found in the northeast part of the area in T. 148 N., R. 103 and R. 104 W. Other small bodies occur farther south, many of which are too limited to be shown in the map. The topography is level or gently sloping, the type usually occupying high plateaus and the upper part of hill slopes. The soil is also commonly found at the base of buttes and around the heads of some of the smaller streams. Except on the level areas the surface drainage is usually well established. The formation is chiefly residual, though in a few places the character of the soil is slightly affected by the presence of glacial gravel.

A peculiar feature of the soil is the frequent occurrence of small depressed areas, on which the surface materials appear to have been burned away, a condition similar to that found on the Carrington clay loam of the Carrington area. In some instances these areas represent merely "slides" of the water-soaked soil, but in others the vegetation and soil have doubtless been oxidized by the chemical action of alkali salts in the underlying clay stratum. In such places vegetation has been slow to recover its growth and consists of little more than small withered cacti. Though alkali is visible on the surface only in restricted areas, it is probable that the greater part of the type is somewhat affected by its presence This is evidenced by the scant growth of native prairie grass which covers much of the soil. In its present condition the type provides considerable pasturage and could doubtless be as well employed for this purpose as for the growth of cultivated crops.

[a] The word coulée is here used as locally understood.

The following table gives the average results of mechanical analyses of the soil and subsoil of this type:

Mechanical analyses of Morton clay loam.

Number.	Description.	Fine gravel.	Coarse sand.	Medium sand.	Fine sand.	Very fine sand.	Silt.	Clay.
		Per cent.	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*
17665,17667	Soil	0.1	1.1	0.5	5.5	8.6	60.4	23.2
17666,17668	Subsoil	.1	.3	.4	3.5	13.6	50.9	30.9

The following samples contained more than one-half of 1 per cent of calcium carbonate ($CaCO_3$): No. 17665, 5.86 per cent; No. 17666, 2 per cent; No. 17668, 6.76 per cent.

MORTON STONY LOAM.

The soil of Morton stony loam consists of 6 to 12 inches of brown fine sandy loam or yellowish-brown silt loam, containing from 10 to 50 per cent of smooth, rounded gravel. The stones are chiefly granitic in character and range from one-half inch to 3 inches or more in diameter. Large granite bowlders are also occasionally found embedded in the soil, but their occurrence is not common. The subsoil is usually a yellowish-brown silt loam with a somewhat smaller percentage of gravel than is found in the soil.

The Morton stony loam is the most limited soil type in the McKenzie area, being found only in the northwestern part in bodies ranging from 3 or 4 acres to a quarter section in extent. Many areas, too small to be shown on the map, are seen along the banks of streams and on the higher elevations throughout the Morton silt loam.

The Morton stony loam occurs as low, narrow ridges and rounded knolls, which, together with the open structure, give excellent drainage at all times.

The origin of the Morton stony loam is both glacial and residual. The gravel was carried by the ice from the regions to the north and deposited in its present position during Glacial time. Subsequently the stones became mixed with the finer residual material, though they are rarely found below a depth of 3 feet.

The native grasses found are usually rather short, especially during the dry, summer months, but, owing to the rapidity with which the soil dries out in spring, these knolls and ridges are the first to offer pasturage after the snows have disappeared.

Were it not for the difficulties of cultivation on account of the rolling topography, the soil would be adapted to the growing of potatoes, corn, vegetables, and other crops where earliness and freedom from frost are essential. As it is, the type is used only for pasture.

ROUGH BROKEN LAND (BAD LANDS).

Rough broken land is a term used in the McKenzie area to indicate a surface condition rather than a distinct soil type. Throughout the

west the areas are known as "Bad Lands." As the name implies, the surface features are extremely rough and rugged, which condition has given rise to a great variety of soil materials. On the bare sides of eroding buttes the soil consists of light-colored silty clay with a slight admixture of very fine sharp sand. On the tops of hills and ridges, where the silt and sandy materials have not been washed away, the soils are identical with the Morton silt loam and Morton fine sandy loam. These areas, though numerous, are usually very small, rarely exceeding a few acres in extent. On the steep sides of deep, narrow ditches which run between the buttes the soils range from silty clays to clean, sharp sand.

Not all of the lands in the McKenzie area having a rugged topography, however, are mapped as Rough broken land. The soils on many such areas possess a remarkable uniformity, and wherever this condition obtains the materials are mapped, according to texture, as Scoria gravel, Morton silt loam, or as Morton fine sandy loam, regardless of topographic features. Hence, only three extensive bodies of Rough broken land appear in the map. Of these, the one occurring along Prairie Dog Creek, in the southeast part of the area, is the largest and most important. This body, consisting of buttes, ditches, and high vertical walls, is continuous with the Rough broken lands along the Little Missouri River. The other bodies of the type are found on the east side of Bennie Pierre Creek in the northwest part of the area and in the western part of T. 147 N., R. 104 W. Other minor bodies are found associated with Scoria gravel hills in all parts of the area.

The topography of all these bodies is extremely rough, steep-sided valleys being found from 50 to 300 feet in depth and from one-fourth to one-half mile in width, separated from each other merely by a long, narrow ridge. Travel in such a region is very difficult and in many places quite impossible.

The Rough broken land owes its present condition almost entirely to erosion. Because of the admixture of fine, sharp sand in the silt and clay this action is proceeding at a very rapid rate. Each year the ditches grow deeper and their heads push farther and farther back into the level areas, so that the buttes and valleys are not only growing in numbers, but the areas of Rough broken land are continually spreading.

A large part of these rough lands is more or less affected by alkali salts. In places these have collected and formed a white crust over the surface of the ground, and where this has occurred vegetation is very scant.

The areas of Rough broken land are especially valuable for their extensive deposits of lignite coal. These veins underlie large areas and run from 1 foot to 8 or 10 feet in thickness.

On account of the activity of erosion in the Rough broken land numerous small bodies are found on which vegetation is exceedingly scant. The narrow valleys, however, and the lower parts of the buttes are usually covered by a moderate growth of native prairie grass. Occasional springs are also found in the valleys, and though the water is usually salty it is rarely so strong as to be rejected by stock. The occurrence of these springs and the shelter from the winds which the ditches and buttes afford make these areas especially desirable as a winter range for stock. The land is worthless for cultivated crops and should be used exclusively as pasture.

SUMMARY.

The McKenzie area comprises ten townships in the southwest corner of McKenzie County on the State line between North Dakota and Montana. Parts of the area are extremely rough and broken and the drainage is well established.

No agriculture is practiced in the area, the leading industry being the raising of stock. This is due to several causes, of which are: (1) The absence of adequate facilities for transportation, the nearest shipping points being Wibaux, Mont., 33 miles to the south, and Williston, N. Dak., 35 miles to the north; (2) the marked adaptability of the region to this special industry, beef cattle and horses being grazed the year around without any provision being made for their subsistence; and (3) the general lack of faith on the part of the people in the certainty of crop production without irrigation in the semiarid belt.

The region is very sparsely settled, only twelve ranches occurring within the area surveyed. All of these people are ranchmen of considerable experience.

Aside from the areas of Rough broken land, eight soil types were mapped. Of these, the Morton silt loam has the greatest development. For agricultural purposes this is the best upland soil in the area. During favorable years it should produce fair yields of small grains, hay, and potatoes.

The Morton fine sand and Morton fine sandy loam are the earliest soils, and enjoy the most freedom from frosts during the growing season. During the summer they are somewhat affected by drought, but with thorough cultivation should be adapted to potatoes and early truck.

In general the Wade silt loam of the valleys is the best land in the area. On this type irrigation could be practiced at small expense by constructing embankments across the valleys to withhold the annual floods of snow water in the spring, for use during the growing season. When this is done, the type will be well adapted to al-

falfa, small grains, potatoes, and a wide variety of crops. In its present condition the soil produces from one-half ton to 1½ tons of prairie hay per acre, though it is chiefly used for pasturage.

The Rough broken land, as its name implies, is extremely broken in topography. The areas consist chiefly of buttes, ditches, and high vertical walls, making cultivation impossible. The occurrence of springs and the shelter from winds which the ditches and buttes afford make the type especially desirable as a winter range for stock. Throughout the type occur vast deposits of lignite coal, which are especially valuable in this treeless region.

The McKenzie area is located on the line between the farming country of the east and the ranching country of the west. Either of these industries could well be supplemented by the other, but if either is to be practiced to the exclusion of the other the live-stock industry should unquestionably predominate.

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U.S. DEPT. OF AGRICULTURE
BUREAU OF SOILS
MILTON WHITNEY, CHIEF.

SOIL MAP
NORTH DAKOTA
McKENZIE SHEET

AGRICULTURAL AND ECONOMIC GEOLOGICAL SURVEY
OF NORTH DAKOTA
DANIEL E. WILLARD, DIRECTOR.

SOIL PROFILE
(3 feet deep)

Morton stony loam — Fsl / Sil

Morton fine sand — Fs / Fs

Morton fine sandy loam — Fs / Fsl

Morton silt loam — Sil / Sil / Sic

Morton clay loam — L / Cl

Wade silt loam — Sil / Sil

Wade clay — Hcl / C

Scoria gravel — Fs

LEGEND

Sil	Silt loam
Fs	Fine sand
Fsl	Fine sandy loam
Hcl	Heavy clay loam
C	Clay
L	Loam
Cl	Clay loam
Sic	Silty clay

LEGEND

Ms	Morton stony loam
Mfs	Morton fine sand
Mf	Morton fine sandy loam
M	Morton silt loam
Mc	Morton clay loam
W	Wade silt loam
Wc	Wade clay
S	Scoria gravel
R	Rough broken land (Bad lands)

Soils surveyed by
A. E. Kocher, assisted by R. P. Stevens
of the Agricultural and Economic
Geological Survey of North Dakota.
1907.

0 1 2 3 4
Scale 1 inch = 1 mile

A. Hoen & Co. Lith. Baltimore, Md.

Field Operations
Bureau of Soils
1907